

### WHAT IS CLAIMED IS:

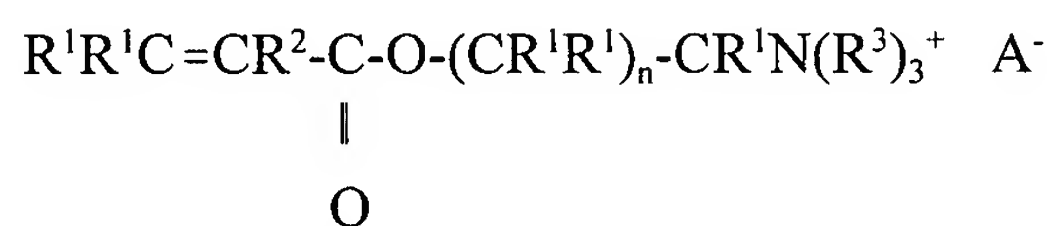
1. A composite membrane, said composite membrane being prepared by a process comprising the steps of:

- (a) providing a proton exchange membrane;
- (b) introducing a cationic monomer into one or more desired areas of the proton exchange membrane; and
- (c) effecting the polymerization of the cationic monomer.

2. The composite membrane as claimed in claim 1 wherein the cationic monomer is a quaternary salt monomer.

3. The composite membrane as claimed in claim 2 wherein the quaternary salt monomer includes a cationic component and an anionic component, said cationic component being selected from the group consisting of acrylic, methacrylic and ethynyl esters of quaternary ammonium alkanes and acrylic, methacrylic and ethynyl esters of quaternary ammonium heterocycles.

4. The composite membrane as claimed in claim 3 wherein the quaternary salt monomer is of the formula

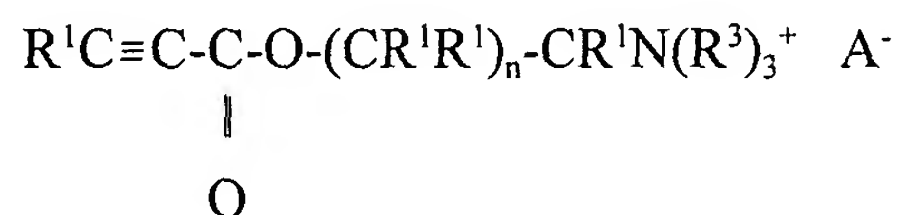


wherein  $\text{R}^1$  is selected from the group consisting of F and H,  $\text{R}^2$  is selected from the group consisting of H, a methyl group and a halide,  $\text{R}^3$  is selected from the group consisting of a methyl group and an ethyl group,  $n$  is 0-3, and  $\text{A}^-$  is an anion with which the cation exhibits solubility in water.

5. The composite membrane as claimed in claim 4 wherein A<sup>-</sup> is selected from the group consisting of sulfate and chloride.

6. The composite membrane as claimed in claim 3 wherein said cationic component is selected from the group consisting of trimethyl ammonium ethyl acrylate and dimethylammonium ethylmethacrylate.

7. The composite membrane as claimed in claim 3 wherein the quaternary salt monomer is of the formula



wherein R<sup>1</sup> is selected from the group consisting of F and H, R<sup>2</sup> is selected from the group consisting of H, a methyl group and a halide, R<sup>3</sup> is selected from the group consisting of a methyl group and an ethyl group, n is 0-3, and A<sup>-</sup> is an anion with which the cation exhibits solubility in water.

8. The composite membrane as claimed in claim 7 wherein A<sup>-</sup> is selected from the group consisting of sulfate and chloride.

9. The composite membrane as claimed in claim 3 wherein said quaternary ammonium heterocycles are selected from the group consisting of pyridinium, pyridazinium, pyrimidinium, pyrazinium, imidazolium, pyrazolium, thiazolium, oxazolium and triazolium.

10. The composite membrane as claimed in claim 1 wherein said proton exchange membrane is a perfluorosulfonic acid proton exchange membrane.

11. The composite membrane as claimed in claim 1 wherein said polymerization effecting step comprises heating the product of step (b).

12. The composite membrane as claimed in claim 1 wherein said polymerization effecting step comprises irradiating the product of step (b).

13. The composite membrane as claimed in claim 1 wherein said polymerization effecting step comprises exposing the product of step (b) to a free-radical catalyst.

14. The composite membrane as claimed in claim 1 wherein said one or more desired areas into which said cationic monomer is introduced consist of the entire periphery of said proton exchange membrane.

15. The composite membrane as claimed in claim 1 wherein said one or more desired areas into which said cationic monomer is introduced consist of the entire periphery of said proton exchange membrane and one or more interior regions for segmenting the proton exchange membrane into two or more circumscribed areas.

16. A composite membrane, said composite membrane comprising:

(a) a proton exchange membrane; and

(b) a cationic polymer incorporated into an area of the proton exchange membrane, said cationic polymer replacing membrane protons in said area of said proton exchange membrane.

17. The composite membrane as claimed in claim 16 wherein the proton exchange membrane is a perfluorosulfonic acid proton exchange membrane.

18. The composite membrane as claimed in claim 16 wherein said cationic polymer is incorporated into the proton exchange membrane only along its periphery.

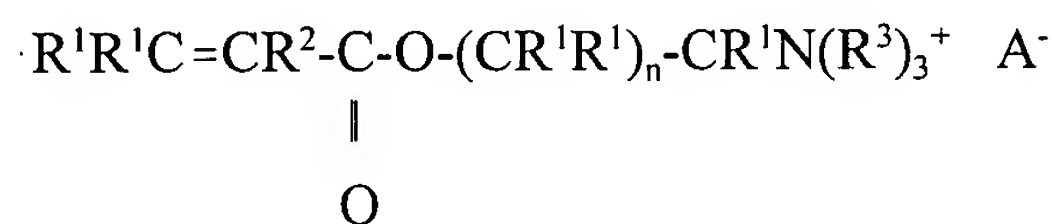
19. The composite membrane as claimed in claim 16 wherein said cationic polymer is incorporated into the proton exchange membrane along its periphery and along one or more interior

regions thereof to divide the proton exchange membrane into a plurality of unmodified, circumscribed segments.

20. The composite membrane as claimed in claim 16 wherein said cationic polymer is formed from a quaternary salt monomer.

21. The composite membrane as claimed in claim 20 wherein the quaternary salt monomer includes a cationic component and an anionic component, said cationic component being selected from the group consisting of acrylic, methacrylic and ethynyl esters of quaternary ammonium alkanes and acrylic, methacrylic and ethynyl esters of quaternary ammonium heterocycles.

22. The composite membrane as claimed in claim 21 wherein the quaternary salt monomer is of the formula

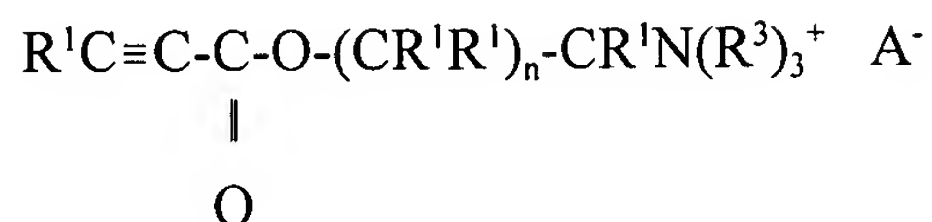


wherein  $\text{R}^1$  is selected from the group consisting of F and H,  $\text{R}^2$  is selected from the group consisting of H, a methyl group and a halide,  $\text{R}^3$  is selected from the group consisting of a methyl group and an ethyl group,  $n$  is 0-3, and  $\text{A}^-$  is an anion with which the cation exhibits solubility in water.

23. The composite membrane as claimed in claim 22 wherein  $\text{A}^-$  is selected from the group consisting of sulfate and chloride.

24. The composite membrane as claimed in claim 21 wherein said cationic component is selected from the group consisting of trimethyl ammonium ethyl acrylate and dimethylammonium ethylmethacrylate.

25. The composite membrane as claimed in claim 21 wherein the quaternary salt monomer is of the formula



wherein  $\text{R}^1$  is selected from the group consisting of F and H,  $\text{R}^2$  is selected from the group consisting of H, a methyl group and a halide,  $\text{R}^3$  is selected from the group consisting of a methyl group and an ethyl group,  $n$  is 0-3, and  $\text{A}^-$  is an anion with which the cation exhibits solubility in water.

26. The composite membrane as claimed in claim 25 wherein  $\text{A}^-$  is selected from the group consisting of sulfate and chloride.

27. The composite membrane as claimed in claim 21 wherein said quaternary ammonium heterocycles are selected from the group consisting of pyridinium, pyridazinium, pyrimidinium, pyrazinium, imidazolium, pyrazolium, thiazolium, oxazolium and triazolium.

28. An electrochemical device comprising:

(a) a composite proton exchange membrane, said composite proton exchange membrane comprising

(i) a proton exchange membrane, and

(ii) a cationic polymer incorporated into a first portion but not a second portion of the proton exchange membrane, said cationic polymer replacing membrane protons in said first portion of said proton exchange membrane;

(b) an anode electrically coupled to a first face of said second portion of said composite proton exchange membrane;

(c) a cathode electrically coupled to a second face of said second portion of said composite proton exchange membrane;

(d) an anode chamber in fluid communication with said anode;

(e) a cathode chamber in fluid communication with said cathode; and

(f) means for electrically interconnecting said anode and said cathode.

29. The electrochemical device as claimed in claim 28 wherein said first portion of said composite proton exchange membrane consists of the periphery of said proton exchange membrane.

30. The electrochemical device as claimed in claim 28 wherein said first portion of said composite proton exchange membrane comprises the periphery of said proton exchange membrane and one or more interior regions defining a plurality of circumscribed segments.

31. The electrochemical device as claimed in claim 28 wherein said cationic polymer is formed from a quaternary salt monomer.

32. The electrochemical device claimed in claim 31 wherein the quaternary salt monomer includes a cationic component and an anionic component, said cationic component being selected from the group consisting of acrylic, methacrylic and ethynyl esters of quaternary ammonium alkanes and acrylic, methacrylic and ethynyl esters of quaternary ammonium heterocycles.

33. The electrochemical device as claimed in claim 28 wherein said electrochemical device is a fuel cell.

34. The electrochemical device as claimed in claim 28 wherein said electrochemical device is an electrolyzer.

35. The electrochemical device as claimed in claim 28 wherein said electrochemical device is a electrochemical gas concentrator/compressor.

36. The electrochemical device as claimed in claim 28 wherein said electrochemical device is a sensor.

37. The electrochemical device as claimed in claim 28 wherein said electrochemical device is a supercapacitor or ultracapacitor.

38. The electrochemical device as claimed in claim 28 wherein said electrochemical device is an industrial electrochemical process unit.

39. A membrane electrode assembly comprising:

(a) a composite proton exchange membrane, said composite proton exchange membrane comprising

(i) a proton exchange membrane, and

(ii) a cationic polymer incorporated into a first portion but not a second portion of the proton exchange membrane, said cationic polymer replacing membrane protons in said first portion of said proton exchange membrane;

(b) an anode electrically coupled to a first face of said second portion of said composite proton exchange membrane; and

(c) a cathode electrically coupled to a second face of said second portion of said composite proton exchange membrane.

40. The membrane electrode assembly as claimed in claim 39 wherein said first portion of said composite proton exchange membrane consists of the periphery of said proton exchange membrane.

41. The membrane electrode assembly as claimed in claim 39 wherein said first portion of said composite proton exchange membrane comprises the periphery of said proton exchange membrane and one or more interior regions defining a plurality of circumscribed segments.

42. The membrane electrode assembly as claimed in claim 39 wherein said cationic polymer is formed from a quaternary salt monomer.

43. The membrane electrode assembly as claimed in claim 40 wherein the quaternary salt monomer includes a cationic component and an anionic component, said cationic component being selected from the group consisting of acrylic, methacrylic and ethynyl esters of quaternary ammonium alkanes and acrylic, methacrylic and ethynyl esters of quaternary ammonium heterocycles.

44. A method of preparing a composite membrane, said method comprising the steps of:

(a) providing a proton exchange membrane;

(b) introducing a cationic monomer into one or more desired areas of the proton exchange membrane; and

(c) effecting the polymerization of the cationic monomer.

45. The method as claimed in claim 44 wherein proton exchange membrane is a perfluorosulfonic acid proton exchange membrane.

46. The method as claimed in claim 44 wherein said cationic monomer is a quaternary salt monomer.

47. The method as claimed in claim 46 wherein the quaternary salt monomer includes a cationic component and an anionic component, said cationic component being selected from the



group consisting of acrylic, methacrylic and ethynyl esters of quaternary ammonium alkanes and acrylic, methacrylic and ethynyl esters of quaternary ammonium heterocycles.

48. The method as claimed in claim 44 wherein said one or more desired areas of the proton exchange membrane consist of the periphery of the proton exchange membrane.

49. The method as claimed in claim 44 wherein said one or more desired areas of the proton exchange membrane comprise the periphery of the proton exchange membrane and one or more interior regions defining a plurality of circumscribed segments.

50. The composite membrane as claimed in claim 44 wherein said polymerization effecting step comprises heating the product of step (b).

51. The composite membrane as claimed in claim 44 wherein said polymerization effecting step comprises irradiating the product of step (b).

52. The composite membrane as claimed in claim 44 wherein said polymerization effecting step comprises exposing the product of step (b) to a free-radical catalyst.